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RESEARCH ACTIVITIES IN THE DESIGN AND MAINTENANCE OF SONAR TRAN--ETC(U)

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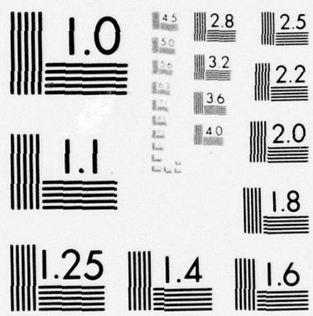

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

FINAL SUMMARY REPORT

Research Activities in the Design and
Maintenance of Sonar Transducers

By V. Salmon and E.M.Spurlock
Stanford Research Institute

March 1969

For Naval Ship Systems Command

Contract N00024-68-C-1077
Project S2720, Task 11685

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Research Report

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6 # RESEARCH ACTIVITIES IN THE DESIGN AND MAINTENANCE OF SONAR TRANSDUCERS.

10 By: VINCENT SALMON EUGENE M. SPURLOCK

Prepared for:

NAVAL SHIP SYSTEMS COMMAND
WASHINGTON, D.C. 20360

ATTN: 00V3M

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CONTRACT NO. N00024-68-C-1077, NOBsR-89004
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STANFORD RESEARCH INSTITUTE
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Final Summary Report

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S R I Project PAU-7125

Approved: VINCENT SALMON, MANAGER
Sonics Program

G. A. MARXMAN, DIRECTOR
Physical Sciences (Physics and Chemistry of Fluids)

MARJORIE W. EVANS, EXECUTIVE DIRECTOR
Physical Sciences Division

Copy No. 19

ABSTRACT

This report summarizes research conducted since 1959 for the Navy Ship Systems Command, under Contracts NObsr 89004 and N00024-68-C-1077 and the successor Contract N00024-69-C-1123.

In the general area of improving the reliability of sonar transducers, three specific problem areas have been attacked: transducer improvement, maintenance engineering, and test and evaluation.

Under transducer improvement we have studied details of corona and arc breakdown, and have developed a mechanical semidestructive procedure for locating weak ceramic rings. Failed transducers have been studied, and recommendations made for design improvement.

Maintenance engineering has been concerned with determining and improving acoustical and equipment limitations of transducer repair facilities (TRFs). A possible site for a test facility at Bodega Head has been studied thoroughly. The test facilities at all TRFs have been evaluated and recommendations have been made for improvement and ultimate standardization.

The test and evaluation problem has resulted in an outline of the various tests that are or will be required. The concept and detailed research plan have been developed for a device for the automated prognosis and diagnosis of sonar transducer operating condition (PADSTOC).

Appendix A lists reports generated as part of the above effort. In Appendix B the funding for direct and contributory contracts is given. Appendix C indicates the effort in man-years, funding for this effort,

and major procurements for contracts is specifically directed toward transducer improvement. Appendix D gives work statements and objectives of present effort under Contract N00024-69-C-1123.

CONTENTS

INTRODUCTION

The ocean is an impersonally hostile environment in which man or machine attempts to operate. The history of the Navy is in large part the story of restraining this environment and controlling its effects. Among the lessons learned is that any specific problem cannot be considered apart from others. Too many system failures have occurred because some seemingly unimportant aspect of the environment was not considered.

In the light of the above remarks, this final report presents somewhat more than a statement of activity under the subject contract since the last report. It is a summary, a synthesis of all contract activities, plus reference to related studies that have contributed to an enriched understanding of the problems under investigation.

The presentation is based on areas of difficulty associated with transducer test, evaluation, maintenance, and improvement. The pertinent contracts are noted where appropriate.

SUMMARIES OF PROGRAM AND RELATED SRI EFFORT

Work by SRI has been in two large related programs: transducer improvement, and transducer maintenance engineering, test, and evaluation. In Tables 1 and 2 below we list the activities in each program area, together with the corresponding SRI efforts. In the body of the report we note these additional contributions in summarized form, with reference to reports where detail may be found. Table 3 lists the problem areas in which SRI has been active. The results of this SRI activity have been or can be applied directly to each aspect of the life cycle (mission profile) of a sonar system.

Table 1

TRANSDUCER IMPROVEMENT

Program Activities	Areas of SRI Effort
Study failed transducers	Failure analysis
Determine causes of failure	Shock, corona, ceramics, coupling
Study design improvement	Shock, corona, ceramics, coupling
Write manufacturing specifications	Shock, corona, ceramics, coupling

Table 2

TRANSDUCER MAINTENANCE AND TEST/EVALUATION ENGINEERING

Determine Maintenance/Repair Facility Status, and Capabilities	Perform work at Naval shipyards at Portsmouth, N.H., Boston, Norfolk, Charleston, San Diego, San Francisco, Puget Sound, Pearl Harbor. Study Bodega Head site. Measure underwater environment, including boundary reflectivity and ambient noise at selected facilities.
Determine Needs of Ideal M/R Facility	Participate in STEP, MART Committee activities. Provide engineering coordination.
Devise Test/Evaluation/Diagnostic Equipment	Devise bench tests Write T&E specifications Develop PADSTOC concepts.
Perform Bench Tests	Use devices/procedures developed for purpose.
Perform Repair	Select corona-resistant insulation, coatings, procedures, couplants.
Verify Restoration of Specified Performance	Use reverberation tank technique Use recommendations from surveys.
Restore System Evaluation	Provide engineering assistance.

Table 3

SRI ACTIVITY IN
PROBLEM AREAS OF LIFE CYCLE (Mission Profile)

Transducer

Step	Problem Areas
Develop specification	Corona, electrical shock, gas filling, mechanical shock, moisture resistance, test and evaluation specification
Select raw materials	Adhesives, ceramics, coatings, couplants, elastomers, insulation, pressure release, tension rod
Fabricate subassemblies	In-process tests
Assemble	Acoustic holography
Make shipment	Effects of altitude, temperature, rough handling
Store	Effects of temperature, sun, water
Install	Nearfield/farfield correlations
Use, monitor	Simplified PADSTOC on board
Maintain, repair	Full PADSTOC at TRF Reverberation tank evaluation
Reuse	Analysis of failed elements

Table 3 (continued)

Allied Components

Component	Problem Areas
Transmitter	Sailor-proof power settings, spark gap protection against overvoltage from explosive attack
Scanning Switch	Clean room techniques
Domes	Antifouling, elastomers, clean water filling
Signal processing	Synthetic signals to test system Synthetic aperture techniques

EARLY RESEARCH

In this section we discuss research that preceded and led to the present effort. The initial research was done under contract Nonr 3049(00), in which we conducted in 1959 a study on nearfield/farfield transducer radiation pattern relations. Various analytical and experimental approaches were evaluated and some were selected for further investigation at SRI.

In 1961 an SRI project team was set up under contract Nonr 2332(00) to advise the U.S. Navy on its broad research program, and to recommend roles for the several BuShips laboratories. The project team office was in the (then) Bureau of Ships. From this study we gained valuable insights into the systems aspects of problems associated with a wide variety of naval operations. The research was one of the several tasks assigned to this contract by the Office of the Chief of Naval Operations and the Office of Naval Research. Other tasks included a study of radiated noise versus detection capabilities, and use of rivers as a sound channel for detecting low flying aircraft.

Of more specific use in transducer problems was later work under contract Nonr 3049(00), in which nearfield/farfield relations were studied. In a comparison of Trott array and Helmholtz-Kirchhoff integral techniques for processing data used obtaining these relations, it was concluded that both procedures were fundamentally much the same. Indeed, it is not too much of a simplification to state that the Trott array procedure uses analog data-processing techniques, whereas the H-K integral employs digital calculations. The general study concluded in a report by A. Picker et al. issued November 1961.[1]

One of the general results of the study was recognition of the need for rapidly determining the performance of transducers. One specific need was to measure the total power radiated from a transducer into a tank too small to provide directivity pattern and output power by pulse measurement techniques. We suggested using a reverberation tank procedure to supply the analog of integrating over the pattern to get total sound radiated. This concept was investigated under contract NObsr89004. The approach used the fact that, to determine power by a reverberant tank technique, two pieces of experimental information are needed: the space average steady-state sound pressure level, and the rate of decay of level after the transducer is turned off. For this purpose a phase coincidence method was adapted from aerial acoustics to obtain decay rate. In this method the transducer and hydrophone are kept a constant distance apart, and the signal frequency is slowly changed. From the number of phase coincidences per unit frequency interval between the input electrical signal and the received acoustic signal, the decay rate can be calculated. The scheme is useful in calculating total acoustical output (and hence efficiency) for transducers having appreciable bandwidth. To avoid unacceptable change in radiation impedance, the ratio of tank to transducer diameter should be greater than 3. The cost of the test tank facility used was shared between SRI and the Navy. The results of the studies were summarized in a final report by E. M. Spurlock.[2]

In contract NObsr86699, transducer experience was used in investigating automatically hardening soft mounts for naval vessel machinery. The concept studied was that of using the charge developed by a ceramic transducer during underwater explosive attack to actuate means of clamping machinery in position during passage of the explosive shock wave. Without such clamping, soft mounted machinery requires considerable rattle space to avoid damaging impact with hull and other machines. The clamping

devices studied could reduce the rattle space in addition to strengthening mounts which otherwise might fracture due to shock excitation.

Further contributions to the enrichment of transducer improvement and maintenance research have come from three additional sources. The Institute is a member of the National Security Industrial Association. Dr. Salmon of SRI is a member of their Antisubmarine Warfare Advisory Committee, and attends Navy briefings. For security purposes he is a Class C consultant, and receives appropriate documents. Dr. Salmon has also been appointed by the National Academy of Sciences to its Panel on Submarine Noise Measurement, which is working through the Committee on Undersea Warfare. A third enrichment of the transducer research came from contracts Nonr 3947(00) and N00014-67-C-0182, for the Naval Ship Research and Development Center. The properties of the near and farfields of incoherent noise radiators were studied and an interim technical report issued.[3] It offers means for predicting the space-average field near the transducer. A final report has just been issued.

TRANSDUCER IMPROVEMENT RESEARCH

Follow-on studies under NObsr89004 for the (now) Naval Ship Systems Command include a variety of tasks dealing with sonar transducer performance evaluations, improvement, and maintenance. Further tasks were added under Contract N00024-68-C-1077 and its most recent continuation, N00024-69-C-1123. The tasks may be classified under the headings of transducer improvement, maintenance engineering, and test/evaluation:

Transducer Improvement	Maintenance Engineering	Test and Evaluation
Failure analysis	Environmental surveys	Test specifications
Corona	Facilities surveys	PADSTOCK
Shock	Couplants	
Ceramics	Bodega Head	
MART	STEP	

A continuing analysis of the causes of transducer failures is being conducted as failed elements become available to SRI. This program has two chief aims. The first is to attempt to correlate the results of external electrical measurements with the actual internal physical condition of the transducer elements (with sufficient data on the previous mission profile, it may also be possible to reconstruct the failure history). If sufficient correlations are found, then the second (and long-range) goal of providing data inputs for use in a transducer operating condition evaluation system (such as PADSTOC) will be satisifed.

In a more immediate sense, results of the analysis can be used directly to improve the construction, use, and repair of existing transducers.

Transducer failure mechanisms are being analyzed at SRI through the use of standard laboratory electrical methods at both high and low input levels, through analysis of samples of internal gas content by mass spectroscopy and gas chromatography techniques, and by visual examination and electrical measurement of components after opening. Until October 1968, the number of transducer units available for inspection was too small for statistically useful data. Hence preliminary information on findings has been transmitted by letter. The importance of tension rod design has been noted: it should be constructed of fatigue-resistant steel, and the screw threads should have rounded bottoms to avoid stress risers. Electrical breakdown is common, and requires proper materials and construction techniques for coatings, insulation, and avoidance of sharp edges; such techniques are common in high-voltage engineering.

The design of breakdown-resistant ceramic transducers requires that degradation produced by corona be small enough inside the enclosed element to permit at least a five-year life. At present it is not possible to specify this limiting amount of corona without some basic research. Accordingly, present transducer improvement efforts are devoted to elimination of corona and effects. Three lines of attack are recommended: (1) elimination of all sharp or small-radius conductors as solder points; (2) use of corona-resistant coatings over active ceramic materials in the transducer element; and (3) use of insulation (as silicones and "Kapton") that resists corona and has relatively inert degradation products. Detailed information appears in three Summary Reports,[16,20,21] and in SRI letter of 13 December 1968 to G. Moore, forwarding a description of a general investigation program on designing against electrical breakdown in transducers.[23]

Ceramic transducer elements are particularly vulnerable to shock forces transverse to the axis of the element, because the large tail mass is cantilevered from the radiating face. Such shock can arise from underwater explosive attack or from slamming of the vessel in heavy seas. At SRI, studies on the shock problem have been concerned with the adequacy and fields of usefulness of the various underwater shock simulation devices employed for in-process and acceptance testing. A general conclusion is that there needs to be a reassessment of shock resistance criteria for transducers that show brittle rather than plastic failure; presently used scaling laws assume plastic failure. At the UERD Portsmouth facility explosive attack is well simulated. However, we recommend that the elements tested should be terminated in normal loads, to determine if the shock-generated voltages expected in service are sufficiently high to make the controlling effect that of catastrophic voltage breakdown rather than mechanical failure. These and other conclusions are discussed in Summary Reports No. 3[11] and No. 6.[17]

The mechanical integrity of the ferroelectric rings used in ceramic transducers is vital to the shock resistance of the transducer. The Institute has developed a proof test for similar rings, using rapidly applied hydrostatic pressure at the inner ring surface. Initial studies, reported orally at the MART Materials Committee meetings, have suggested that such a proof test might be used to cull weak rings from a production run. The research, conducted by the Ceramics Processing group in our Materials Processing and Engineering Laboratory, is continuing with a larger sample of rings to get statistically significant results.

Common to all aspects of the transducer improvement effort is participation in the MART program and its operating committees. The Institute plays an active role on these committees, and has provided detailed engineering advice on a variety of specific problems.

Studies under Maintenance Engineering have been concerned with facilities evaluation, and with specific maintenance and repair problems.

SRI, in cooperation with the Applied Research Laboratory (ARL) of the University of Texas at Austin, is currently conducting a survey of facilities and equipment for sonar restoration, test, and evaluation at all Naval Shipyards for the Sonar Systems Office of NAVSHIPS. The purpose of the survey is, after realistically ascertaining the strengths and limitations of shipyard equipment and personnel with respect to the sonar restoration environment, to recommend optimum methods, procedures, and equipment for use in the repair, installation, test, and evaluation of all component equipment of surface and submarine shipboard sonar systems. It is hoped that standardized methods can be devised for many of the operations involved and that standardized test equipment can be recommended. The end result is to further assure the quality of the sonar system afloat, and to ensure that the performance of all shipyards will be equally dependable in the field of sonar maintenance. A survey of facilities at six suppliers of sonar transducers was reported in Summary Report No. 8.[22] There is considerable variation in capabilities and competence, and standard tests (such as those using equipment similar to that employed in the TRF standardized evaluation console) are badly needed.

Environmental measurements of facilities to be used for the underwater evaluation of sonar transducers have been conducted for the Sonar Systems Office. The principal measurements have been concerned with the acoustic absorption and reflection characteristics of the underwater boundaries, and the long-term spectral distribution of the underwater ambient acoustic noise. Initial studies were conducted at the test tank at San Francisco Bay Naval Shipyard, Vallejo. Limitations of the tank led to a search for better sites for calibration. An abandoned nuclear

reactor pit located at Bodega Head, Sonoma County, California, appeared most promising as a site, and was evaluated by SRI for its underwater acoustic boundary reflectivity characteristics and ambient noise level. The results of the evaluation were presented in Summary Report No. 1.[5]

During 1967, the Applied Research Laboratory of the University of Texas (ARL) and SRI collaborated in an underwater acoustic environmental survey of all transducer repair facility (TRF) test sites. This survey was required to furnish basic facility evaluation data for use in developing the NAVSHIPS Standardized Transducer Evaluation Program (STEP) for Navy shipyards. The recommendations for the Program had to be based on realistic knowledge of the limitations as well as the potentials of the available test sites. Computerized data reduction procedures were employed by SRI for the reduction of all the ambient noise data collected during the survey, and for its graphical and tabular presentation in one-third octave frequency bands.[19] A feature of the SRI data reduction is the presentation of spectra with time as the parameter. From such a plot the effect on measurements can be predicted.

The recommendations of the survey have led to a search for additional test sites to augment the existing sites. Currently, SRI is evaluating a possible site for high-level testing at Vallejo, and will shortly evaluate a proposed site for hydrophone testing at Pearl Harbor. Improved computer techniques will be used to reduce and present the data currently being collected; the results with appropriate recommendations will be published as an SRI Summary Report.

Because accurate knowledge of transducer operating condition is required by ships operating in forward areas, SRI and ARL will investigate the feasibility of establishing test areas at Ship Repair Facilities in the Western Pacific region. Any test areas considered will be fully evaluated environmentally before being selected for use.

A continuing problem in restoring transducers is to assure tight acoustical coupling of the face of the transducer element to the external elastomer boot used on many transducers. Several alternatives to the traditional castor oil couplant were investigated at SRI. Although no final specification change can be recommended until full-scale tests have been completed, it does appear that Dow Corning type 11 compound can offer up to 6 dB advantage over the castor oil. The detailed results are given in Summary Report No. 10.[24] As recommended in that report, a controlled evaluation of DC-11 under shipyard use conditions is under way.

SRI activities in maintenance engineering have been coordinated through the Standardized Transducer Evaluation Program (STEP) Committee, of which E. M. Spurlock is a participating member.

Test and evaluation of sonar transducers is undertaken for several purposes: for manufacturing control, to determine compliance with specifications, to determine operating condition in service, and for diagnosing failures when a transducer is brought in for repair. Programs on T&E at SRI have been concerned with all of these tasks. Presently under way is a codification of detailed test procedures for use in manufacturing transducers under a construction type of specification. T&E for determining both compliance with specifications and operating conditions was studied in collaboration with other Navy contractors. The detailed program is presented in Summary Report No. 2.[6] Details of some measurements proposed appear in Summary Report No. 4.[12]

Part of the activities in T&E have been devoted to the development of an automated measurement device for the prognosis and diagnosis of sonar transducer operating condition (PADSTOC). With the increasing complexity of sonar systems and the decreasing availability of maintenance personnel with the necessary qualifications, some type of automated inspection will eventually become necessary. The advanced sonar

technology program for accomplishing this is expected to require a lead time of three to seven years, depending on the level of effort. Technical details of the development program are discussed at length in Summary Report No. 7.[18] The development program is based on a model (or a full-scale) transducer into which reversible, synthetic defects can be introduced at known locations and in known amounts. At present this long term program is accorded low priority.

Appendix A

REPORTS LISTING

The SRI reports chronologically listed below were prepared under the ONR and NAVSHIPS programs described above. Not all are referenced in the text. Progress Reports are omitted.

1. Prediction of farfield performance of some projectors from nearfield measurements: A. Picker et al., November 1961. Final Report, Nonr 3049(00).

2. Transducer evaluation by a reverberant tank method; E. M. Spurlock, February 1965. Final Report, NObsr 89004.

3. Radiation of spatially incoherent noise: point and line sources: V. Salmon, K. N. Sawyers, and R. J. Bromelow, January 1968. Interim Technical Report, N00014-67-C-0182.

4. Examination of failed TR177, TR197 elements; E. M. Spurlock to J. Whiteley, 23 December 1965. Technical Letter, NObsr 89004.

5. Feasibility investigation of a Bodega Head facility for the calibration of Navy transducers (U); E.M. Spurlock, 24 March 1966 CONFIDENTIAL. Summary Report No. 1, NObsr 89004.

6. Transducer T&E systems program; V. Salmon, 27 April 1966. Summary Report No. 2, NObsr 89004.

7. Notes on meeting of Transducer Materials and Techniques Subcommittee of Transducer Program Planning Committee, 6 October 1966; V. Salmon, Copy to Evans. Technical Letter, NObsr 89004.

8. Transducer Materials Committee meeting of 6 October 1966; Notes; V. Salmon to Dr. Paul Smith, NRL, 3 November 1966. Technical Letter, NObsr 89004.

9. Magnetostrictive Materials Seminar, at TRACOR/DC, October 1966; notes by V. Salmon, 15 November 1966; copy to Glenn Moore. Technical Letter, NObsr 89004.

10. Naval Engineering Acoustics syllabus, V. Salmon to H. Evans, 14 April 1967. Technical Letter, NObsr 89004.

11. Shock resistance of sonar transducers; D. R. Grine, V. Salmon, 3 May 1967. Summary Report No. 3, NObsr 89004.

12. Feasibility study of selected in-situ measurements on operational transducers; C. W. Smith, 17 May 1967. Summary Report No. 4, NObsr 89004.

13. List of non-Navy laboratory people active in sonar transducer technology, V. Salmon to 00V1D2, 18 August 1967. Technical Letter, NObsr 89004.

14. Low-level impedance vs. temperature, E. M. Spurlock to H. Evans, 29 December 1967. Technical Letter, NObsr 89004.

15. Transducer failure investigation outline, and specific failure mechanisms observed, notes from E. M. Spurlock to H. Evans, 29 December 1967. Technical Letter, NObsr 89004.

16. Preliminary report on corona problems; C. W. Smith, 12 June 1968. Summary Report No. 5, N00024-68-C-1077.

17. Shock testing of sonar transducers (U); D. R. Grine, July 1968; CONFIDENTIAL. Summary Report No. 6, N00024-68-C-1077.

18. Prognosis and diagnosis of sonar transducer operating condition: concepts; V. Salmon, 29 July 1968. Summary Report No. 7, N00024-68-C-1077.

19. An environmental survey of the Naval Shipyard transducer test facilities; D. D. Baker and E. M. Spurlock, DRL Report DRL-TR-68-25, August 1968. Joint Report.

20. Corona specification conference (U); V. Salmon, 16-17 July 1968; CONFIDENTIAL. Status Report, N00024-68-C-1077.

21. Corona testing in TR-208 transducer elements (U); C. W. Smith, 16 September 1968; CONFIDENTIAL. Summary Report No. 9, N00024-68-C-1077.

22. Survey of transducer hydroacoustic testing facilities (U); H. A. Thorpe, 20 August 1968; CONFIDENTIAL. Summary Report No. 8, N00024-68-C-1077.

23. Program outline of investigation on designing against electrical breakdown in transducers, V. Salmon to G. Moore, 13 December 1968. Technical Letter, N000-68-C-1077.

24. Evaluation measurements of selected transducer acoustic couplants; E. M. Spurlock, 31 December 1968. Summary Report No. 10, N00024-68-C-1077.

25. Internal operating temperatures of Edo TR203 elements (U), E. M. Spurlock to G. Moore, 10 September 1968; CONFIDENTIAL. Technical Letter, N00024-68-C-1077.

26. TR197 teardown and examination, E. M. Spurlock to J. H. Riley, NAVSEC, 19 September 1968. Technical Letter, N00024-68-C-1077.

27. Adequacy of hydroacoustical facilities for sonar transducer testing, H. A. Thorpe to H. Evans, 20 November 1968. Technical Letter, N00024-68-C-1077.

28. Radiation of Spatially Incoherent Noise: Circular and Rectangular Plane Sources, V. Salmon and K. N. Sawyers. Final Report, November 1968, N00014-67-C-0182.

Appendix B

CONTRIBUTING AND DIRECT CONTRACT EFFORT ON TRANSDUCER IMPROVEMENT PROBLEMS

Contributing Contracts

Fiscal Year(s)	Contract Number	SRI Project	Total Approximate Funding to Date
1961	Nonr 2332(00)	2167	$ 35,000(1)
1960,61	Nonr 3049(00)	3077	78,080
1962,63,64	NObsr 86699	4109	42,240
1963,64	Nonr 3947(00)	4363	66,640
1967,68	N00014-67-C-0182	6285	53,400

Notes: (1) This funding is for the portion of the effort applicable to the transducer problem. Total effort, for 11 fiscal years, was $12,000,000.

Direct Contracts

Fiscal Year(s)	Contract Number	SRI Project	Total Approximate Funding to Date
1963 thru 1967	NObsr 89004	4220	$ 249,650
1968	N0024-68-C-1077	7125	126,420
1969	N0024-69-C-1123	7646	135,440

Appendix C

FUNDING AND ACTIVITY
ON CONTRACTS ON TRANSDUCER IMPROVEMENT PROGRAMS

Contract	NObsr 89004				
Fiscal Year	1963	1964	1965	1966	1967
Labor Funding	$36,490	$46,717	$44,571	$43,744	$72,888
Man-years	1.35	1.6	1.5	1.4	2.2
Major Procurement	2110	1889	--	--	1244
Total Funding	$38,600	$48,606	$44,571	$43,744	$74,132

Contract	N00024-68-C-1077	N00024-69-C-1123
Fiscal Year	1968	1968
Labor Funding	$125,528	$130,628
Man-years	2.7	2.7
Major Procurement	895	4811
Total Funding	$126,423	$135.,439

Appendix D

WORKSTATEMENTS AND LONG AND SHORT TERM OBJECTIVES OF PRESENT SRI EFFORT UNDER CONTRACT N00024-69-C-1123

Task 1 - Failure Analysis

Conduct analysis of failed transducer elements to determine failure history and mechanisms and recommend corrective action. Complete analysis on SQS-4, 23, 26 and BQS-6 transducers. Final report shall be published summarizing work effort in this area with input by Tracor. Report shall include recommendations for improvements in design, production, and repair.

A. Long-Term Objective

The long-term objective of the failure analysis task is to collect and interpret data on sonar transducer element failures and to recommend appropriate corrective actions.

B. Short-Term Objective

The short-term objective of the failure analysis task is to collect and interpret data specifically on SQS-4, -23, -26, and BQS-6 transducer element failures and to recommend appropriate corrective actions.

Task 2 - Improved Materials and Test Techniques

Conduct investigation of improving ceramic ring reliability by analyzing SQS-23 and 26 rings for uniformity and making screening tests to determine ceramic strength.

A. Long-Term Objective

The long-term objective is to develop ferroelectric ceramic materials for transducers that will yield improved shock resistance without unacceptable compromise of other operating characteristics.

B. Short-Term Objective

The short-term objective is to perform a feasibility study on state-of-the-art means for improving ferroelectric ceramic shock resistance.

Task 3 - Prognosis and Diagnosis of Sonar Transducer Operating Conditions (PADSTOC) Devices Development

Develop tests and procedures for indicating the type, location, and extent of single defects in a multielement transducer that satisfactorily models the construction of the SQS-23 or 26. Final specification will be forwarded at termination of contract for determination of continuing Task 3.

A. Long-Term Objective

The long-term objective of the PADSTOC development is to provide the fleet with a series of automated, computerized, pattern-recognizing diagnostic and prognostic devices for detecting, locating, and identifying unacceptably out-of-tolerance elements in an installed sonar transducer.

B. Short-Term Objective

The short-term objective is to perform initial studies on developing and automating test procedures for rapidly locating the more common transducer element defects, using only the electrical terminals of the element.

Task 4 - Corona Detection

Develop a production test for detecting elements susceptible to corona and arc discharge. Determine reasons for and corrective measures against corona in transducers.

A. Long-Term Objective

The long-term objective of this task is to develop, design, and construct prototype production and diagnostic test devices for detecting the presence and estimating the extent of corona or arc discharge within a sealed transducer element.

B. Short-Term Objective

The short-term objective is to develop a prototype production test device for measuring the voltage threshold at which corona or arc discharge takes place within a transducer element.

Task 5 - Transducer Repair Facility (TRF) and Shipyard Improvement and Standardization

Participate in STEP Committee activities; participate in planning, evaluation, site survey, installation, training, use and data processing aspects of transducer measurement and calibration systems; and participate in East and West Coast shipyard survey in areas of bench,

high-pressure and onboard transducer tests. Survey will take approximately three weeks.

A. Long-Term Objective

The long-term objective is to provide for each TRF an easily operable system that will produce transducer test and evaluation data uniform in format and numerically consistent among the several TRF's. Pre- and post-installation test standardization will ensure the quality of the final installed product.

B. Short-Term Objective

It is the objective of this task to assist in the standardized transducer evaluation program (STEP) by development of equipment and procedures for bench, tank, and open-water evaluation of transducer elements.

Task 6 - Shipyard Modernization and Mart Program

Analyze and evaluate areas of transducer T&E Systems; analyze instrumentation and make environmental surveys whenever necessary; participate in math-modeling and reliability transducer (MART) program committee meetings; and aid in formulating necessary transducer specifications.

A. Modernization

Long-Term Objective. The long-term objective is to ensure that reliable absolute and compatible data on transducers are obtained at non-TRF shipyards.